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Invention: INTER-SYSTEM HANDOVER -- GENERIC HANDOVER MECHANISM

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SPECIFICATION

INTER-SYSTEM HANDOVER - GENERIC HANDOVER MECHANISMS

FIELD OF THE INVENTION

This invention relates to mobile radio systems and in particular mobile radio handoff procedures.

BACKGROUND AND SUMMARY OF THE INVENTION

The first public mobile radio systems were introduced in the late 1970's and early 1980's. As a group, those now well-known systems were referred to as "first generation" systems. They included the "Advanced Mobile Phone System" (AMPS) in the United States, "Nordic" in Scandinavia, "Total Access Communications System" (TACS) in Britain, and "Nippon Mobile Telephone System" (NAMTS) in Japan. They had certain transmission characteristics that were generally common to all, such as analog frequency modulation at the radio and digital control at the network. Otherwise, however, each system used a communication standard unique to itself in comparison to the others.

The so-called "second generation" mobile radio systems began their introductions in the mid- to late-1980's. The first of these was

the "Group Special Mobile" (GSM) system which became the standard in Europe. The United States followed with "Digital AMPS" (DAMPS), the TDMA version of which was sometimes referred to by its standardization name, "IS-54." The Japanese second generation system was called "Personal Digital Cellular" (PDC). Each of these systems had their own peculiar transmission characteristics and channel conditioning.

Presently, a number of initiatives are being proposed for the "third generation" of mobile radio systems. European third generation system research is being coordinated by the "Universal Mobile Telephone System" (UMTS) initiative, which is studying various proposals including wide-band CDMA (WCDMA), improved TDMA, hybrids, etc. Japanese initiatives for third generation are called "IMT-2000" and are focusing on wide-band CDMA. "Future Public Land Mobile Telecommunications System" (FPLMTS) is another proposed third generation network.

Mobile phones for the third generation systems will be intelligent multi-mode terminals for communication with first, second and/or third generation systems. A basic problem arises, however, in designing the third generation systems in that they must be backward compatible with all second generation systems. If a third generation system is to communicate solely with a like kind of second generation system, the modifications may be straightforward. However,

cooperation between countries employing disparate second generation systems is increasing. The European standards organization, ETSI, and the Japanese standards organizations, TTC and ARIB, are suggesting hand-off capability for third generation systems to both the European second generation system (GSM) and the Japanese second generation system (PDC).

PDC and GSM protocols (as well as other second generation systems) are unique to each other. GSM as well as PDC, specifies frequencies (f) and time slots (TS) in a way unique to each system, second generation systems employing CDMA specify appropriate codes, and other second generation systems use other kinds of protocol specifications. These protocols for second generation systems are well-known throughout the industry. In the example case of PDC and GSM compatibility to third generation UTMS, the PDC and GSM specifications can be adapted to provide forward compatibility. So too can UMTS specifications be adapted for backward compatibility. In the case of UMTS, however, the standard will have to be compatible to multiple different kinds of second generation communications protocols, depending upon the type of second generation system a UMTS network is in communication with at any given time.

The problem is particularly keen as it relates to hand-off procedures. As a mobile radio is handed off from a UMTS service area to a PDC service area, for example, the protocol change must be

accommodated from the third generation system characteristics to the PDC second generation characteristics. The same would be true if the mobile radio signal connection was handed from a UMTS system to any other second generation system. Thus, in the above example, the UMTS would be required to communicate to PDC networks in a PDC compliant protocol, to a GSM network in a GSM compliant protocol, etc. The third generation system ends up supporting multiple mechanisms, namely PDC and GSM (among potentially others).

Previously, when systems were upgraded from first generation to second generation, backward compatibility was an issue that was addressed. Handoff techniques from, for example, analog signaling to digital signaling, were accommodated through various techniques. Such techniques included, for example, signal acquisition, modulation, and re-alignment (re-synchronization) aspects. These techniques were thus highly content-specific, requiring newer generational system to be fully, substantively conversant with previous generational systems. Content-specific AMPS to DAMPS handovers were also developed to accommodate first generation to second generation system upgrading. Such prior handoff systems did not address the problems associated with handing off signals from a new generation of system to multiple different kinds of previous generation systems.

The present invention provides a highly efficient way of ensuring that handoffs from third generation systems to multiple

different kinds of second generation systems is done efficiently and without disruption. Thus, for example, third generation UMTS systems can ensure communication with any kind of second generation system, including DAMPS, GSM, PDC, etc.

In accordance with a preferred embodiment of the invention, a generic mechanism is provided to accommodate inter-system handovers between third generation systems and any other type of system including any type of second generation system. The generic mechanism includes a standardized data "container" structure that will include whatever information is necessary to specify a communication to a neighboring cell system in the communication language (whether common or foreign) of that neighboring cell system. Thus, for example, if a handover to a GSM neighboring cell is to occur, the container may specify the communication parameters for a GSM transmission. On the other hand, if the neighboring cell is PDC specific, the container may specify the communication parameters for a PDC transmission. Any other types of third, second, first, or other communication parameters can also be specified in the container. Using the container, the recipient of the handover can specify the communication parameters to the mobile radio, and the mobile radio can specify its capabilities to the neighboring cell using the proper parameters. Importantly, the current cell (for example, third generation) need not read and interpret the content of the particular second generation parameters in the container, provided it simply

delivers the container to the neighboring cell for evaluation. In this way, the third generation system need not understand all previous generation protocols and the recipient second (or first) generation system is fooled into believing that it is communicating with another second (or first) generation system.

BRIEF DESCRIPTION OF THE DRAWINGS

These, as well as other objects and advantages of this invention, will be more completely understood and appreciated by careful study of the following more detailed description of a presently preferred exemplary embodiment of the invention taken in conjunction with the accompanying drawings, of which:

FIGURE 1A is a schematic presentation of an example mobile radio system;

FIGURE 1B is a schematic depiction of an example mobile radio system including multi-generational systems;

FIGURE 2 is a communication sequence depiction in accordance with a preferred embodiment of the present invention;

FIGURE 3 is a representation of broadcast system information from a network to a mobile station (third generation cells treated like foreign generation cells);

FIGURE 4 is a representation of broadcast system information from a network to a mobile station (third generation cells treated differently compared to foreign generation cells);

FIGURE 5 is a representation of mobile capabilities information communicated from the mobile station (third generation cells treated like foreign generation cells);

FIGURE 6 is a representation of mobile capabilities information communicated from the mobile station (third generation cells treated differently compared to foreign generation cells);

FIGURE 7 is a representation of neighboring cell information communicated from the network (third generation cells treated like foreign generation cells);

FIGURE 8 is a representation of neighboring cell information communicated from the network (third generation cells treated differently compared to foreign generation cells);

FIGURE 9 is a representation of measurement instruction information communicated from the network (third generation cells treated like foreign generation cells);

FIGURE 10 is a representation of measurement instruction information communicated from the network (third generation cells treated differently compared to foreign generation cells);

FIGURE 11 is a representation of cell measurement report information communicated from the mobile station (third generation cells treated like foreign generation cells);

FIGURE 12 is a representation of cell measurement report information communicated from the mobile station (third generation cells treated differently compared to foreign generation cells);

FIGURE 13 is a representation of handoff command information communicated from the network (third generation cells treated like foreign generation cells);

FIGURE 14 is a representation of handoff command information communicated from the network (third generation cells treated differently compared to foreign generation cells);

FIGURE 15 is a representation of inter-network handoff information communicated from an RAN to a CN; (third generation cells treated like foreign generation cells); and

FIGURE 16 is a representation of inter-network handoff information communicated from an RAN to a CN (third generation cells treated differently compared to foreign generation cells).

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENT

The following example embodiment is described with respect to second generation systems such as GSM and PDC and third generation systems such as UMTS. However, the fundamental aspects of the present invention are more generically applicable to all kinds of foreign system handovers. The preferred embodiment of the present invention is employed in combination with multi-mode mobile phones, i.e., mobile phones capable of communicating with at least two different types of mobile phone systems under corresponding multiple different types of communication protocol standards. Such multi-mode mobile phones can communicate with two or more of, for example, GSM, PDC, UMTS, etc. systems. The preferred embodiment of the present invention will have equal applicability to all types of multi-mode mobile phones presently available and developed in the future. That is, the present invention provides a generic mechanism for intersystem handover, regardless of the communication protocol specification of the systems involved in the handover, or the type of multi-mode mobile radio employed.

A preferred embodiment of the present invention involves a generic mechanism to provide intersystem handovers between a UMTS system and a GSM or PDC system. This occurs when, for example, a mobile phone in a UMTS service area is handed over to a cell being supported by a GSM or PDC system. In such a case, the dual- (or multi-) mode mobile phone communicates with the UMTS system in accordance with UMTS protocols and is also capable of communicating with the GSM and PDC systems in accordance with their respective protocols.

As used herein, the term multi-mode mobile phone shall mean dual-mode mobile phones and other mobile phones capable of community according to two or more different communication protocols.

An example mobile radio system structure is shown in Figure 1a. In this particular structure, a third generation UMTS system 10 is shown as including mobile stations 30 communicating over a radio interface to base stations 28. Base stations 28 are included within UMTS terrestrial radio access network UTRAN which includes both radio network controllers 26 and base stations 28. Similarly, mobile stations 30 can communicate through base station 23 to base station controller BSC 22. However, the base stations 23 and BSC 22 are not part of UMTS, as seen in Figure 1B.

The BSC 22 and UTRAN 24 communicate via interfaces "A" and "Gb", and "RAN IF" to respective core network service nodes. These nodes include the mobile switching center MSC 18 for circuit switched services and general packet radio service node GPRS 20 for packet switch services. These nodes in turn communicate with public service telephone network/ISDN node 12 or Internet node 14, respectively.

As depicted in Figure 1A, base station system 22 and base station 23 may comprise a second generation cellular system such as GSM or PDC. Mobile station 30 communicating with the base station 23 will employ an appropriate GSM or PDC protocol format for such communications. By the same token, mobile stations 30 in communication with the UMTS terrestrial radio access network 24, i.e., a third generation cellular system, communicate with the network via a UMTS standard protocol. When mobile stations move from a cell serviced by base station 28 to a cell serviced by base station 23, a handoff is created between a third generation system to a second generation system. In such cases, the mobile stations 30 must be multi-mode mobile radios capable of communicating in both second generation protocols and third generation protocols.

Figure 1B is a schematic representation of an extension of Figure 1A in which mobile radios communicate with second generation systems, third generation systems, and any other type of cellular

system presently available or available in the future. In such cases, the coordination of communication between these systems is made more effective and efficient through use of the present invention.

The present invention recognizes that the third generation cellular system of, for example Figures 1A and 1B, in order to effectuate a handoff procedure, must be capable of communicating the handoff requirements to and from the disparate cellular systems to which the handoff is occurring. One way to do this is to educate the third generation system about the communication protocols for each and every previous generation cellular system to which handoff may occur. Such a task is daunting given the possible numbers of second generation systems (and other prior systems) to which the third generation cellular system may have to handoff a mobile radio communication.

The present invention provides a more generic mechanism that allows system handovers from third generation cellular systems to any other type of system.

There are several different types of communication between the network and the mobile radio that should have the generic support offered by the present invention in order to solve the problem identified. In reference to Figure 2, some of these kinds of communications are discussed. With respect to Figure 2, a second generation base station is shown on the left side of the Figure, and a

dual-mode (or multi-mode) mobile station is shown on the right. Between the dual-mode mobile station and the second generation base station is the UMTS terrestrial radio access network UTRAN which is servicing the cell in which the mobile stations are currently communicating. In the embodiment shown in Figure 2, the mobile station is preparing to be handed off from the UMTS cell through the core network CN structures to a cell serviced by the second generation base station shown on the left of Figure 2. Thirteen different communications are described in Figure 2 in order to illustrate the generic mechanism used by the present invention with respect to certain of these communications.

Communication step 1 in Figure 2 is a broadcast of system information from the UMTS system to the mobile stations acting in otherwise idle mode, i.e. to single mode mobile stations as well as multi-mode mobile stations. In this communication step 1, the network supplies the mobile station in idle mode (i.e., not in communication with the network except through receipt of the broadcast information on the control channel of a cell) with neighboring cell information for at least the cell serviced by the second generation base station on the left of Figure 2. As shown in step 1, the broadcast system information from the third generation UTRAN can include information in a so-called "container" (described in more detail following) telling the dual-mode mobile stations that handoff capabilities are available in WCDMA mode (third generation) or in any other kind of second

generation mode (GSM/PDC). Of course, the UTRAN communicates with the dual-mode mobile station in the third generation wideband CDMA mode (WCDMA), not in the GSM/PDC/Other protocol, but simply identifies to the dual-mode mobile station that container capability is available through the UTRAN for handoff to other than third generation systems.

After the broadcast system information is sent in step 1, a connection setup procedure is developed in step 2 between the UTRAN and the mobile station. This follows standard connection setup procedures between the network and the mobile station.

In step 3, the mobile radio provides the network with an indication of its radio related capabilities. The mobile radios make this communication to the third generation UTRAN, in this example in WCDMA mode. As part of its capabilities information, the mobile station may also communicate to the network that it is capable of communicating in GSM/PDC/Other modes as well. This information containing the dual-mode aspects of the mobile station is included in the return "container" from the mobile station to the network, as described in more detail below.

In step 4 of Figure 2, the network, which now knows that the mobile station can operate in dual-mode based on the capabilities provided to it in step 3, provides the mobile station with neighboring cell information. This transmission to the mobile station will include

the container information for neighboring cells, whether they are like generation or foreign generation systems.

In step 5, the network provides the mobile station with measurement control information and instructions. Again, this information will include the container for foreign cell measurement control information, as described in more detail below.

Thereafter, the mobile station takes the measurements it was instructed to take from the neighboring cells. The results of the measurements are reported to the network in step 6. These measurement reports for neighboring cells include the container for measurements on the foreign neighboring cells, as described below.

In step 7, the network makes the decision whether to handoff the mobile station to a foreign neighboring cell. Once the decision is made to handoff, the third generation network UTRAN initiates a handoff command through the appropriate core network in step 8 to the foreign neighboring cell base station in step 9. In the case of Figure 2, the foreign neighboring cell is a second generation base station, which issues a handoff command at step 10 back to the core network. The core network relays the handoff command as "Handoff Command B" to the third generation network UTRAN, which in turn delivers the "Handoff Command C" to the mobile station.

Steps 9 and 10 could also be via another MSC, in the same or a different network. The present invention is not limited to a particular network architecture, e.g. an architecture with MSCs and BSs. This architecture is herein only used as an example.

Thereafter, the mobile station is handed off to the second generation base station and therefore begins communication in the second generation protocol (for example, GSM or PDC), in step 11. Finally, the second generation base station (or another second generation node relevant to that particular second generation system architecture) informs the core network that the handoff is complete in step 12 and the core network releases the third generation system resources in step 13.

The presently preferred embodiment of the invention provides generic support between the third generation and second generation systems of, for example, Figure 2 by providing the generic container mechanisms identified above to support several of the communications described in Figure 2. In particular, non-generational (i.e., generic) support is required for the control channel broadcast information (step 1), the mobile capabilities communication (step 3), the neighboring cell information communication (step 4), the cell measurement and reporting instruction (step 5), the cell measurement result communication (step 6), and the handoff command C. In these cases requiring generic support, there is a need for communication between

the third generation network in the mobile station regarding information from a foreign system. For example, in Figure 2, if the second generation base station is a GSM system, the UMTS must communicate with the mobile station regarding foreign GSM information.

There may also be cases of communication with the network that share the same requirement for generic support described above, for example, when transferring a request for handover to another system between a radio network node (RAN node) and a core network node (CN node) or when transferring a handover command between a CN node and a RAN node.

The solution for providing generic communication capabilities between disparate systems is to provide "containers" for foreign system information in a communication transmission. The generic containers allow a non-conversant third generation system to avoid learning multitudes of bilaterally specific procedures in order to communicate second generation (or other generation) information to a dual-mode mobile station, or vice a versa. Examples of how these containers are employed in the generic communications of Figure 2 are shown in detail in Figures 3 through 16.

Figures 3 and 4 are example embodiments of the broadcast system information communication (step 1) of Figure 2. Figure 3 is an embodiment in which third generation cells are treated as any other cell

and Figure 4 is an example of third generation cells being treated differently from foreign cells.

Figures 5 and 6 are example embodiments of the mobile capabilities communication (step 3) of Figure 2. Figure 5 is an embodiment in which third generation cells are treated as any other cell and Figure 6 is an example of third generation cells being treated differently from foreign cells.

Figures 7 and 8 are example embodiments of the neighboring cell information communication (step 4) of Figure 2. Figure 7 is an embodiment in which third generation cells are treated as any other cell and Figure 8 is an example of third generation cells being treated differently from foreign cells.

Figures 9 and 10 are example embodiments of the cell measurement instruction (step 5) of Figure 2. Figure 9 is an embodiment in which third generation cells are treated as any other cell and Figure 10 is an example of third generation cells being treated differently from foreign cells.

Figures 11and 12 are example embodiments of the cell measurement result (step 6) of Figure 2. Figure 11 is an embodiment in which third generation cells are treated as any other cell and Figure 12 is an example of third generation cells being treated differently from foreign cells.

Figures 13 and 14 are example embodiments of the handoff command communication ("Handoff Command B" as well as "Handoff Command C") of Figure 2. Figure 13 is an embodiment in which third generation cells are treated as any other cell and Figure 14 is an example of third generation cells being treated differently from foreign cells.

Figures 15 and 16 are example embodiments of the inter-network handoff communications with CN (step 8) of Figure 2. Figure 15 is an embodiment in which third generation cells are treated as any other cell and Figure 16 is an example of third generation cells being treated differently from foreign cells.

In Figures 3 and 4, the neighboring cell information broadcasted to the mobile station on the control channel in step 1 includes the container for the foreign neighboring cells as the "neighboring cell data (as specified by the specifications for the particular system)" of Figure 3 and "neighboring cell data (as specified by the foreign system)" of Figure 4. A container structure is provided within the data map for each neighboring cell reported. This container is structurally generic to any communication protocol and content-specific to the communication protocol of the particular cell being reported on.

In Figures 5 and 6, the transfer of mobile station capabilities of step 3 of Figure 2 includes the container of capabilities related to the foreign system. This is shown in Figure 5 as the "MS radio

capabilities data (as specified by the specifications for the particular system)," and in Figure 6 as the "MS radio capabilities data (as specified by the foreign system)," One container is provided for each mobile radio capability reported to the network.

In Figures 7 and 8, the neighboring cell information is provided by the third generation network to the mobile station and includes the container for foreign neighboring cells. This is shown in Figure 7 as "neighboring cell data (as specified by the specifications for the particular system)" and in Figure 8 as "neighboring cell data (as specified by the foreign system)." A generic container is provided for each reported neighboring cell to include whatever content-specific protocol data is particular to the system type of each neighboring cell.

Figures 9 and 10 relate to the cell measurement and reporting instruction (step 5) of Figure 2 and provide the mobile station with a container for foreign measurement control information. This is shown in Figure 9, for example as "measurement control data (as specified by the specifications for the particular system)" and in Figure 10 as "measurement control data (as specified by the foreign system)." Containers are provided for each of the neighboring cells being reported upon and will contain data characteristic of the cell type being reported upon.

Figures 11 and 12 relate to the measurement reporting for neighboring cells by the mobile station in step 6 of Figure 2. These

measurement reports include the container for measurements on foreign neighboring cells as shown in Figure 11 as "measurement report data (as specified by the specifications for the particular systems)" and in Figure 12 as "measurement report data (as specified by the foreign system)." Containers are provided for reporting measurement data for each of the cells reported upon by the mobile station.

Figures 13 and 14 relate to the "Handoff Command C" of Figure 2, which is the command sent to the mobile station from the network ordering the mobile station to switch to the new cell (new channel). This command includes the container for the chosen foreign cell (channel) to which the mobile station is switching. Thus, if the second generation base station on the left of Figure 2 has been chosen for the handoff and is a GSM system, the Handoff Command C will include a container having GSM data written by the GSM network informing the mobile station about the appropriate GSM communication protocol characteristics. For example, in the case of GSM, the second generation system will provide the dual-mode mobile station with at least the appropriate frequency, time slots, and maximum power characteristics for the GSM transmissions. In Figure 13, the container is shown as "'handover command' (as specified by the specifications for the particular systems)" and in Figure 14 as "'handover command' (as specified by the foreign system)". Figures 13 through 14 contain only a single container because the cell to which handoff is occurring

has been selected and other neighboring cells are no longer in the communication loop. Accordingly, the container of Figures 13 and 14 will include the handover command in accordance with the specifications dictated by the cell protocol for the selected cell to which the handover is occurring.

As can be seen from the depictions in Figures 3 through 14, the preferred embodiment of the present invention provides a data container having a structure common within third generation systems, second generation systems, etc. in order to transmit foreign data types through any particular system to a destination equipment that can read and understand the information provided in the container. With this embodiment, the third generation system need not consider the contents of the container per se, but can simply hand the contents to the mobile station which can read and understand them as needed. Unlike the mobile station, the third generation network need not have the capability to read or act on the communication protocols of the foreign systems to which handoff is occurring but instead act simply as a conduit to deliver the container of foreign system information to the dual-mode mobile station.

There are also instances of communication within the network itself that share the same problem that can be efficiently remedied with the generic container mechanisms described above. Such inter-network communications include the transferring of a request for a

handover to another system as between a radio access node RAN node and a core network CN node. Figures 15 and 16 show example data maps for communications such as these inside the network. In Figures 15 and 16, as examples, when a handover is required, the radio access network sends a request for that handover to the core network in accordance with the mappings of Figures 15 and 16. Each target cell inquiry includes a container for "cell identifier (as specified by the foreign system)" in Figure 15. Again, this container provides a generic data mechanism that can be communicated by the third generation system to a second generation system but contains information that is foreign-system specific (which the third generation system need not necessarily comprehend). Figure 16 differs from Figure 15 in that the third generation cells are treated independently from foreign system cells. In the third generation cells, the container will always include third generation specific, "cell identifier (according to the UMTS specification)." On the other hand, the foreign target cell containers will include whatever foreign system specific information is appropriate within the generic container structure, "cell identifier (as specified by the foreign system)." In Figure 2 not only the communication from the UTRAN to the CN but also the communication from the CN to the UTRAN when CN sends the "Handoff Command B" to UTRAN can be made efficiently with the generic container mechanism. The Figures 13 and 14 could be seen as

an example not only on the "Handoff Command C" but also as an example of the "Handoff Command B."

In the above example embodiments, UMTS, GSM, and PDC systems are described as examples only. The present container structure is not limited to any one of these systems, but may be employed in any type of currently available system or in future generations of mobile radio systems.

The present invention has the advantage that each of the unique mobile radio systems may continue to communicate in its own specification. There is no need for additional data mechanisms to be included into each of the particular generational systems in order for them to understand the specifications and protocols of prior or subsequent generational systems. Instead, each generational system simply knows to open the container it receives in order to extract the protocol information that it needs for communications. Where a particular generational system does not need the protocol information of a foreign system, it simply transports the container down the communication stream.

The specifications of the container are not particular to the present invention but may be any appropriate data mapping structure provided the structure is generic to all generational systems to which it applies. The contents of the container are, of course, left to the

specifications of the particular generational systems in the appropriate cell neighborhoods.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.